



**NAVAL
POSTGRADUATE
SCHOOL
MONTEREY, CALIFORNIA**

THESIS

**A LEAN SIX SIGMA ANALYSIS OF STUDENT IN-
PROCESSING**

by

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December 2012

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A LEAN SIX SIGMA ANALYSIS OF STUDENT IN-PROCESSING

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ABSTRACT

NPS is a top-tier research university that provides mid-grade officers from the Navy, Army, Air-Force, Marines, and Coast Guard, as well as DoD civilians and foreign partners, the opportunity to study full-time in pursuit of a master's degree. The education gained improves the performance of military officers, which provides for better defense of our nation.

The student in-processing method currently in use is confusing, time-consuming and wasteful of school and service resources. There is little coordination between the different military branches and the school concerning school specific and service exclusive check-in requirements. With little oversight or synchronization, bottlenecks form at several locations within the process, creating poor resource utilization and frustration on the part of the school, service, student and student family.

The primary goal of this project is to study and provide recommendations for improving the student in-processing method at NPS using the Lean Six Sigma methodology.

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LIST OF ACRONYMS AND ABBREVIATIONS

CPT: Captain (U.S. Army)

CTQ: Critical to Quality

DAPA: Drug and Alcohol Program Advisor

DLI: Defense Language Institute

DMAIC: Define, Measure, Analyze, Improve, Control

DoD: Department of Defense

LSS: Lean Six Sigma

MRAP: Mine Resistant Ambush Protection

NVA: Non-value Added

NVA-R: Non-value Added-Required

POM: Presidio of Monterey

SARP: Substance Abuse and Rehabilitation Program

SIPOC: Suppliers, Inputs, Process, Outputs, Customers

TOC: Theory of Constraints

TQM: Total Quality Management

VA: Value Added

VOC: Voice Of the Customer

VTC: Video Teleconference

WIP: Work in Progress

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4. Lt Justin Whipple: NPS Student Services representative, primary stakeholder and key source of implementation and control.

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I. NAVAL POSTGRADUATE SCHOOL IN-PROCESSING; AN OVERVIEW

The Naval Postgraduate School (NPS) is a top-tier research university that provides mid-grade officers from the Navy, Army, Air-Force, Marines, Coast Guard, as well as DoD civilians and foreign partners, the opportunity to study full-time in pursuit of a master's degree. The education obtained improves the performance of military officers which provides for better defense of our nation.

During the past 12 months, the Flag Administration Officer at NPS has received several complaints from students concerning the inefficiency of the new student in-processing method currently in use. The process is often slow, with long wait lines for student identification card photos, medical in-processing, and other required signatures for the student check-in sheets. With little to no campus orientation, students are left on their own to navigate on and off campus in search of obscure offices in unfamiliar buildings. Additionally, each military branch has separate, service-specific requirements for in-processing. All the above difficulties are exacerbated since the in-processing is to be completed while many new students are settling themselves and their families into their new environment in Monterey.

The Flag Administration Officer asked the business school to conduct research concerning process improvement whereby the NPS could provide better service to the student body and improve incoming students' first impression of the institution.

The Lean Six Sigma (LSS) methodology was used to conduct the process improvement research. LSS has a well-defined five step framework that is used to guide research towards defining the problem, measuring the processes, making analysis of the information in order to make improvements and set control for sustainable change. Our project team worked on behalf of the Flag

Administration Officer and Student Services to conduct research on the current in-processing method and to make suggestions and recommendations concerning improvement.

A. CASE STUDY OF A NPS STUDENT

This case study illustrates the potential difficulties and inefficiencies associated with the NPS in-processing method as experienced from the new student perspective. The researchers interviewed Captain (CPT) Johnson (not his real name) to get an Army Officer's perceptive and experience with in-processing at NPS. CPT Johnson is an Army infantry officer who has just returned from his second deployment to Afghanistan. He has a wife, two kids and over 14 years of service in the military. The researcher asked CPT Johnson to describe his experience from the time he entered the front gate through the completion of the in-processing process at NPS. Below is a summary of his remarks.

CPT Johnson arrived in Monterey to attend NPS with no information other than the location of the school. He received no check-in directions prior to his arrival. Once he got to the gate he asked the guard where to go for the new student brief. There were no signs to direct new students to King Hall, much less the actual location of King Hall on the NPS campus. He walked into Hermann Hall and asked for directions at the hotel reception desk. After finally making it to King Hall, he received a brief from NPS staff members. The new student brief, which lasted about one hour, contained an overview of what was expected of officers in student status and a quick description of the Monterey area. At the conclusion of the brief, the students were informed that they have one week to in-process and that Student Services will provide them with their check-in sheet. He proceeded to Student Services to obtain the check-in sheet and to get his orders stamped. He was met by a line of at least 150 students at the bottom of Hermann Hall waiting for the same thing. Once he finally got into the Student

Services office, he observed only four clerks working on this process leading to the large bottleneck he just experienced. He estimated his wait time to be 45 minutes.

After getting his orders stamped and leave paperwork signed, he then waited another half hour, in the Student Services office, to get a photo for an NPS identification card. After his photo was taken he was informed that he will get an e-mail indicating when he can return and pick up his new identification card. Then Student Services handed him the in-processing checklist. By the end of the first day, CPT Johnson was already frustrated with how inefficiently his time was spent and worried that a similar theme would persist throughout his in-processing experience.

CPT Johnson explained to us that housing was a big concern for all students whether they are going to live in military housing or reside off base in the local area. It took several days to find a suitable place and arrange for household goods delivery. CPT Johnson had to account for all his personal property, make claims on damaged property, and unpack and set-up all his household goods. Connecting power, changing mailing addresses, insurance changes, stocking the kitchen with food, setting up cable, phone and Internet connections took over a week. The entire move process took two weeks and had to be scheduled around required check-in procedures.

CPT Johnson began day two at the Presidio of Monterey Army Medical Clinic, where, as an Army officer, he was required to complete medical in-processing. He then headed back to the NPS campus to in-process at the Naval Dental Clinic. He then had to go through the security clearances at "GL B-13"; however, he did not know what "GL B-13" was or where to find it. Again, CPT Johnson went to the hotel reception desk to find out where this building was located. The front desk clerk, who was not associated with the school or familiar with in-processing, became his most valuable source for information on building locations on campus. Because the Army uses Fort Jackson in South Carolina to manage all the officers that are in university programs all over the country, CPT

Johnson had to communicate through a video teleconference (VTC) with Fort Jackson concerning Army specific check-in requirements. The staff at Fort Jackson explained in detail all of the paperwork that they needed in order to provide him financial information such as Temporary Lodging Assistance and changes to his Basic Allowance for Housing rate. The VTC took about 3 hours. At the conclusion of the brief CPT Johnson had to find the library—again, an unknown location. In order to send all the documents to Fort Jackson, CPT Johnson had to scan the documents and e-mail them to a junior soldier who would input all the information into a data base. It subsequently took an additional three weeks for CPT Johnson to get his housing allowance to be corrected to reflect the higher cost of living in Monterey and to be reimbursed for the 10 days that he had to stay in a hotel while trying to find a place to live. After dealing with Fort Jackson, he then went to the Sloat gate to register his vehicle and get a pedestrian gate pass. After that, he had a meeting with his Army Representative on campus who welcomed him to the school and signed his check-in sheet. Later that day, there was another meeting with the business school, then a meeting with his specific program administrator within the business school and finally a meeting with the Army student representative who collected his leave forms to turn in to Fort Jackson. CPT Johnson was then required to go to Fleet and Family Support Services, located at Fort Ord, where he received information about family opportunity and assistance provided. At the end of the week, after he had been all over the campus and surrounding areas trying to find places to get signatures to complete his in-processing checklist, the NPS Foundation hosted a “meet and greet” for new students. This entire process took the entire five days, not including the time required to move into his new home in Monterey.

The above hypothetical yet representative case study illustrates much of the inefficiency and variation present in the NPS new student in-processing method. There are clearly areas in which process lead time can be reduced, process quality can be improved and process variation can be minimized. With

this case as a base illustration, the research team applied LSS tools and methods to collect data in order to quantify the inefficient process experienced by incoming students and identify areas and suggestions for improvement.

B. PROBLEM IDENTIFICATION

The student in-processing method currently in use is confusing, time-consuming and wasteful of school and service resources. There is little coordination between the different military branches and the school concerning school specific and service exclusive check-in requirements. With little oversight or synchronization, bottlenecks form at several process steps creating poor resource utilization and frustration on the part of the school, service, student and student family. Little guidance is provided to new students and families as they begin their graduate education experience. Poor management of resources has resulted in inefficient use of NPS staff and excessive waste of time and money for both the new student and the university. The reception and process itself can be unwelcoming and fails to showcase the beauty of the campus, the wealth of resources within, and the premier staff and faculty of Naval Postgraduate School. By using the LSS methodology, this project conducted research on the issues causing these problems and potential defects that create waste and lower customer satisfaction.

C. STAKEHOLDER ANALYSIS

Stakeholder analysis involves identifying individuals or groups that can affect or be affected by changes to a system. It is important to understand the level of influence they can have on implementing changes as well as the impact of the change on the stakeholder. In LSS, stakeholders are the individuals or groups responsible for lasting change. Initial stakeholder analysis was done to identify potential stakeholders, determine their current level of support for change as well as potential resistance to change. This analysis allowed the team to better focus its research and data collection efforts.

Prior to data collection, we identified the following potential stakeholders:

1. Flag Administration Officer
2. Student Services
3. NPS administration
4. Students
5. Presidio of Monterey Medical (POM) clinic

After identifying the stakeholders, we classified each into one of four categories based on their perceived reaction to change in terms of their potential for cooperation or the potential for resistance to the proposed changes to the in-processing protocol.

We considered four types of stakeholders:

1. Supportive Stakeholder
2. Marginal Stakeholder
3. Non-supportive Stakeholder
4. Mixed Blessing Stakeholder

The Flag Administration Officer is spearheading the effort to make the changes in order to address the complaints that were received from students that recently completed the process. The Flag Administration Officer would be a type 1 Supportive Stakeholder because his support for organizational change is high. His threat of not cooperating is very low because improvements to the process will have a direct positive effect on him. The Flag Administration Officer will be responsible for making this a lasting change at NPS. They will need to be heavily involved with implementation and control through use of management skills and influence on the rest of the organization.

Student Services is a type 2 marginal stakeholder. They agree that something needs to change with the process. However, the staff in Student Services will potentially need to be re-trained depending on the recommended

changes. They have been doing the same process the same way for such a long time that there is potential for resistance to change. In the short term there exists a tendency to revert back to the old ways of doing business. This could potentially impede the lasting changes. The Flag Administration Officer will need to monitor Student Services department very closely to ensure their effort in maintaining the new process remains consistent.

The NPS Administration Office conducts coordination with outside agencies involved in the in-processing procedure which represents, as such, a very important stakeholder. They are, however, a type 4 mixed blessing stakeholder. Although they support the idea of improving the overall process, they are concerned that change will increase their already busy schedule. The NPS administration office could be resistive to change if process improvements are perceived to increase their workload. It will be a very important for the Flag Administration Officer to work with the NPS Administration office concerning potential changes to the in-processing procedures.

The students are stakeholders in that they are the ones that have to actually go through in-processing. They are type 2 marginal stakeholders. Students will be very supportive of the process improvements but will not be willing to put forth much effort to improve the process. They view themselves as customers and not responsible for the process. They see this as an internal process at the school of which they can do nothing to control except offer suggestions on how it can be improved.

POM Medical clinic will be type 3 unsupportive stakeholders in this process change. Currently, students are required to individually turn in their medical records at the Defense Language Institute (DLI) located several miles from NPS. If consolidation is determined to be a process improvement, the Medical Clinic may not be willing to spend two days on the NPS campus to complete medical in-processing. In this situation, the NPS Administration Office would coordinate with the commander of the medical concerning a consolidated check-in process.

It is the responsibility of the Flag Administration Officer to get student services, medical units, and administration to buy into the changes. In its current form, the only stakeholders that are negatively affected by in-processing issues are the students. For student services and the administration this event happens twice a year and they have minimal requirements to complete their part of the process. Changing the system will require more effort on each stakeholder's part which may create reluctance to participate. In Chapter V, the team re-evaluated stakeholder analysis once LSS data collection allowed for accurate change recommendations.

D. INITIAL STAKEHOLDER ANALYSIS RECOMMENDATIONS

For change to occur, stakeholders must feel that they have a voice in any recommended changes. It is important for any LSS team to explain their recommendations to all the stakeholders and allow for constructive feedback. Based on initial stakeholder analysis, it is evident that there will be some resistance regardless of the recommendation. The Flag Administration Officer will have to work with all stakeholders to determine who will cooperate with the changes and which stakeholders will potentially be threatened by organizational change. Once the stakeholder's position on change has been determined Flag Admin will need to use management strategies for each stakeholder in order to achieve the desired organizational change. The type 1 supportive stakeholders' management strategy will require getting the supporter involved with the process. Type 2 marginal stakeholders' management strategy will involve monitoring the marginal stakeholder to ensure that they stay on track with the organizational changes. Type 3 non-supportive stakeholders' management strategy should be to defend against their threats to change and try and mitigate their influence on the organization. Type 4 mixed blessing stakeholders' management strategy will consider a collaborative effort between the stakeholder and flag admin to achieve a cooperative posture.

For the Flag Administration Office to make lasting change within NPS, they will need to utilize the strategies discussed above to make the organizational changes necessary to improve in-processing at NPS. Support for any LSS initiative is dependent upon on picking the right people to implement the change. There are six 'must do's' for managers that wish to set the stage for employee success:

1. Pick the right project
2. Pick the right people
3. Follow the method
4. Clearly define roles and responsibilities
5. Communicate, Communicate, Communicate
6. Support education and training.” (George, Rowlands, & Kastle, 2004, p. 84)

Any recommendations to solve any problems will involve all stakeholders. Associated parties must seek to develop a plan that will cut the process time from five days to less than two days. It is theorized that this can be achieved by through stakeholder coordination and process centralization. This would allow the simultaneous establishment of required check-in stations in a centralized location and will reduce lead time and variation while increasing student compliance and customer satisfaction.

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II. LEAN SIX SIGMA HISTORY

A. INTRODUCTION

This chapter will discuss the background of Lean Six Sigma in four sections. Section one will discuss the origins and methodology behind Lean production. Section two will describe Six Sigma and the history behind the culture. Section three will discuss the Theory of Constraints and its impact on Lean Six Sigma and section four will describe Lean Six Sigma and how the two methodologies were combined.

B. LEAN PRODUCTION

Lean production has its origins with Henry Ford who was the first person to associate cost with process speed. He observed that slow process were wasteful and had a negative impact on production costs and ultimately the price of the product. The Toyota Motor Corporation is generally considered to be the architects of lean production (Maleyeff, 2007, p. 8). The Toyota Production System was the first to master the combination of low cost, high quality and high speed (George, 2002, p. 34). The authors of "Lean Thinking," Womack and Jones, used the term "lean" to describe the process of reducing wasteful activities within an organization. Womack and Jones' book introduced many practitioners to Lean through a five-step application guide: Specify value for the customer's perspective

1. Identify the stream of the processes used to provide value
2. Remove non-value-added activities form the value stream
3. Create pull by having all work initiated by customer demand
4. Strive for perfection

All though traditionally applied in manufacturing, the article "Improving Service Delivery in Government with Lean Six Sigma," states,

Lean was originally motivated by competitive pressures in manufacturing, much of the jargon and many of its techniques apply to manufacturing operations and special efforts must be undertaken to successfully apply Lean to service. However, many of the descriptive and intuitive tools of Lean apply nicely to services, and its overall goals do not conflict with those of the service manager. (Maleyeff, 2007, p.9)

Lean production focuses on speed. Process speed can be measured in terms of process cycle efficiency. Increasing speed means getting rid of steps and procedures that do not contribute to the final product. Lean thinking involves increasing system process velocity and the amount of work in process (WIP). Process velocity is the speed at which a process takes place. An increase in process velocity allows for more opportunities to identify what is not working (George, 2002, p.40). Faster process velocities also provide more opportunity for quality tools to reduce defects (George, 2002 p.4). Time traps are steps in the process cause delays and reduces process efficiency and velocity while increasing costs. In order to increase process velocity, time traps must be identified and prioritized based on amount of time delay they add and eliminated through a top down approach (George, 2002, p.36).

Lean takes a customer centric view of a process. Within any process, Lean thinking identifies three types of steps, viewed from the customer's perspective. Value added (VA) steps are those of which the customer is willing to pay. Non-value added (NVA) steps are seen as not necessary or of no value to the final product. Non-value added required (NVA-R) steps are those that do not add value but are required. These can be steps or procedures that are required by law or necessary to keep the process in motion. Value added steps are those viewed by the customer as valuable or necessary for production of the final product. Lean seeks to identify and enhance value added steps while eliminating wasteful, non-value added steps. Value added steps are quantified by time required and, with total lead time, used to measure the efficiency of a process.

Process Cycle Efficiency = Value Added Time / Total Lead Time (George, 2002, p. 36)

Good process cycle efficiencies vary by industry. On average, a process efficiency of 25% is viewed as an efficient process.

Two other metrics have relative importance to process velocity, particularly in the case of this study. A reduction in WIP means a reduction in process lead time which also increases process cycle efficiency. To measure process lead time the following formula (which is also known as Little's Law) is used:

Process Lead Time = Number of "Things" in Process / Completions per hour (George, 2002, p. 49)

"Things" in this case refer to students in the student in-processing process.

Once process lead time is understood, process velocity can be calculated as follows:

Process Velocity = Number of Activities in the Process / Process Lead Time (George, 2002, p. 49)

By reducing process lead time, process velocity will increase. An increase in process velocity results in less WIP, increase product output and a more efficient system.

C. THE SIX SIGMA CULTURE

Six Sigma has its origins in total quality management (TQM) and statistical process control (Maleyeff, 2007, p.9). Made famous by Motorola, the process is driven by an improvement methodology which focuses on a management system

dedicated to top performance and benefit to customers and corporation alike. The term Six Sigma refers to a process capability measurement which allows only 3.4 defects per million opportunities and an overall yield, percent of production within specification, of 99.9997%. In contrast, a four sigma level capability produces an overall yield of 99.379% but allows for 6,210 defects per million, which is unacceptable in most business or industrial process. Six Sigma views variation as the cause for defects and therefore focusses on its elimination.

Sigma Level	Defects per Million	Yield
6	3.4	99.9997%
5	233	99.977%
4	6210	99.379%
3	66,807	93.32%
2	308,537	69.2%
1	690,000	31%

Table 1. Sigma Level

There are several critical factors for success in Six Sigma. As with Lean thinking, Six Sigma analysis views quality in the eyes of the customer. This customer-centric focus seeks to identify the level of quality the customer associates with the process. Voice of the Customer (VoC) data is important to a Six Sigma analysis because it allows the identification of Critical to Quality (CTQ) requirements. Six Sigma thinking improves product quality by focusing company resources on the CTQ requirements. Defects are identified as steps, processes, or procedures that fail to deliver to a customer's CTQ requirements (George, 2002, p.18).

Six Sigma is resource intensive and involves not only top leadership but teams of employees dedicated to quality improvement. Successful companies often have staff members who dedicate 100% of their time to the identification

and elimination of process variability. These individuals are assisted by a team of part time members and are full endorsed and supported by top management. Six Sigma teams are identified through a belt system similar to martial arts.

Master Black Belts are highly trained and dedicated full time to Six Sigma initiatives. They lead large projects while training green and black belt employees. Black Belts also focus on Six Sigma projects full-time. They lead large projects and manage Green Belt members. Green Belt members participate part time on Black Belt teams. Project teams will also include other part-time members and project sponsors. The overall vision is owned by the executive leadership and disseminated through Deployment Champions who lead unit performance improvements. A shared vision and understanding of the concepts are important at all levels for a successful Six Sigma project.

Six Sigma analyses follow a five step, data driven process designed to identify and eliminate variability and NVA steps. DMAIC stands for Define, Measure, Analyze, Improve and Control. A detailed description of the process is discussed in Chapters IV and V of this thesis.

D. THEORY OF CONSTRAINTS

Popularized in the book “The Goal” by Eli Goldratt, the Theory of Constraints (ToC) applies effectively to Lean Six Sigma efforts. Goldratt analyzed systems in an effort to identify constraints, or bottlenecks. Once the constraint is identified, all efforts are made to relieve the bottleneck associated with the constraint. All other system processes are subordinated by the constraint until the bottleneck is eliminated. With the constraint reduced, the process is again analyzed to identify the next bottleneck and the process repeats itself. The Theory of Constraints methodology is a continuous process. The reduction of bottlenecks improves process lead time which supports Lean efforts. The elimination of bottlenecks also improves process quality which supports Six Sigma efforts. A combination of Lean, Six Sigma and Theory of Constraints methodology produces the maximum process improvement.

E. LEAN SIX SIGMA

The synergistic effects of combining Lean speed with Six Sigma culture was first identified just over a decade ago. Lean Six Sigma provides the managerial concepts for the organization to cut costs from organizational processes, increase process speed and provide improvements in the quality of the overall functions within the organization. Michael George, founder and CEO of George Group Consulting defines Lean Six Sigma as “a methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.” The George Group has done extensive research in Lean and Six Sigma methods and was the first to deploy an integrated Lean Six Sigma process.

The combination of Lean and Six Sigma was a breakthrough in process improvement for service and manufacturing sectors. While Six Sigma efforts can bring a process under greater control, they fail to address issues effecting total mean lead time and variation. For example, company X consistently delivers a quality product with a competitive mean delivery time of 10 days. A customer who expects to receive a product in 10 days is pleasantly surprised when the item arrives in two days. Another customer expecting the same delivery time, is not pleased when the item arrives in 18 days. While the total mean delivery time is still 10 days, the company has one unhappy customer due to variation. A quality product delivered eight days late is not an improvement. The difficult issue is consistently delivering on the mean. Six Sigma is used to reduce variation around the mean while lean is used to shift the mean down. Six Sigma reduces process variation and lean cuts non-value added processes. Together, the process time is shorter and more consistent.

This realization by industry managers illustrated the importance of reducing process lead time and variation in conjunction with quality improvement and statistical control. It soon became evident that the combination of Lean and Six Sigma had a synergistic effect. Quality improvement through Six Sigma efforts allowed an increase in lean speed. With fewer defects per million, less

time was spent on rework which improved process lead time. Speed improvements also improved Six Sigma quality. Faster production cycles provided more opportunities to examine the process and make quality improvements. The combination of Lean and Six Sigma allowed an organization to bring a process under statistical control while improving process speed (George, 2002, p. xii).

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III. LEAN SIX SIGMA EXAMPLES

The Lean Six Sigma approach to process improvement is very versatile and has applications across manufacturing and service sector industries. In several examples, manufacturing lead times have been reduced by as much as 80%, quality costs have been cut by 20% and inventory reduced by as much as 50%. The service sector examples have cut costs by as much as 60% and improve delivery times by as much as 50% through a LSS analysis (Apte, 2009, slide 15). Lean Six Sigma has been used with success by government as well as civilian organizations. In this chapter, we will examine two case studies involving LSS improvements.

The first case study showcases the DMAIC process as outlined by Six Sigma. Important to note in this study is the relevancy of a customer centric focus. Had the company not done a thorough customer analysis, they would not have understood the impact of a purely cosmetic defect. This case study was copied in its entirety from Mittal Consultants and Enterprise (MICON) who specializes in LSS consulting and training.

A. FORMED HELICAL WIRES FOR THE JAPANESE MARKET

This Six Sigma case study looks at how our client's factory was able to break into the Japanese market. For nine years, minor cosmetic issues prevented their products from being approved by Japanese customers. Multiple shots were taken at solving the problem over the years. Lots of money, time, and effort were spent to no avail. When the DMAIC process was finally brought in to tackle the problem, it was solved in three months.

The Problem

In this six sigma case study, we look at a factory in Southeast Asia manufactured formed helical wires as one of their main products. This product

was continually rejected during the approval process for the Japanese market over nine years of trying. There were two main causes for the rejection (and both were cosmetic in nature):

The wires had glue lumps on the surface which the Japanese customers found to be ugly. These lumps were left over from a gluing process the product has to go through to ensure the wires stick and stay together under tension or load.

The wires had scratch marks on the surface which the Japanese customers also found quite unsightly.

Approximately 50% of products had these cosmetic problems and were deemed unacceptable by the Japanese customers.

The factory sold this product to the rest of the world without any problems. The other customers did not seem to mind as the cosmetic issues did not interfere with the product's application—which was to hold electric wires under high stress and load. However, the Japanese are known for their demand of perfect quality and this was no exception.

The Japanese only bought this product from Japanese suppliers as they were able to provide products that met all their standards—whether it be application or cosmetic. This was, of course, quite expensive, but after many attempts the customers were unable to find a cheaper foreign source for this product that met all their quality standards.

The Japanese market was very attractive for the SE Asian factory due to the higher prices and margins that could be achieved. High and consistent volumes were also an attraction. If they could break into the Japanese market, it could mean close to \$8 Million in extra revenue for the factory in the first two years alone.

The Method

A core team was formed to execute the project to eliminate the cosmetic issues.

First, the team involved all the process experts and brainstormed all the possible inputs that could affect the two main outputs—glue lumps and scratches. Over 40 possible inputs were identified.

The team knew that their outputs have to be measurable. How do you measure if a product looks good enough? How do you measure glue lumps? How do you measure if minuscule scratches are acceptable? There was currently no way to measure this. So the team created a measurement system for the outputs with the help of the customers to ensure that both the sides had the same system and methods of measurement. The outputs were now completely measurable.

Next, a C&E matrix was used to prioritize the inputs. It was decided that the top 10 inputs in the C&E matrix would be tested first.

Then, during the analyze phase, the team used tools such as ANOVA and Regression to analyze random samples (passive experimentation). This helped us eliminate three more inputs that did not have a statistically significant impact on our outputs.

The team then went on to use low resolution design of experiments (DOE) to narrow it down to three significant inputs. The epsilon squared of the model with these three inputs was 82%. That means that this model describes 82% of the variation that occurs in this process. In the real world, that is huge!

All the team needed to do now was to optimize the process so that the best settings for the three inputs can be found. These settings should give us the optimal levels for our outputs. A response surface design experiment was done to find the optimal settings.

Finally, controls were put in place to ensure that these inputs remain at their optimal settings.

The Result

The product manufactured under the new process and settings were approved by two major Japanese customers. In just one year, the factory has already sold \$3 Million of this product to the Japanese customers—a huge revenue increase for the factory.

B. LSS IN MRAP PRODUCTION

The next case study comes from Strong America Now. Founded by Mike George, Strong America Now is a non-profit organization that uses LSS tools to analyze and identify wasteful spending in the government sector. Their goal is to reduce government spending by 25% through waste reduction and process improvement.

This case study is an example from the Department of Defense. From 2006 to 2007 the demand for Mine Resistant Ambush Protected (MRAP) vehicles in Iraq grew from 200 to 1500. The increase in demand meant that production had to increase ten-fold from 5 to 50 a day. The problem was magnified by the fact that four private companies produced MRAPs at various locations throughout North America. All four designs were slightly different and the final production steps were conducted by the U.S. Government at a facility in Charleston, SC. The following information was copied verbatim from the Strong America Now website.

That facility was the Space and Naval Warfare Systems Center (SSC) located in Charleston, South Carolina. The Space and Naval Warfare Systems Command (SPAWAR) managed this facility. Due to the variations between the vehicles, integration of the navigation and communications equipment proved to be a very complex process. To meet the ten-fold increased production goal and to overcome the subordinate challenges resulting from lack of a common vehicle

design, SSC leadership turned to the proven process efficiency and quality improvement methodology they had heard about from other organizations within the Navy—Lean Six Sigma (LSS).

The first action taken was to develop a High Impact Core Value Stream (HICVS) map. Its purpose was to create a top-level picture of the entire MRAP production enterprise that enabled leadership to see gaps in process, feedback, relationships and policy, and other key dimensions of the enterprise. Once these gaps were identified, their effects on the overall enterprise were assessed. These assessments established a sound basis for assigning priorities for follow-on “deep dive” analyses and focus areas.

The HICVS map provided the ASN (RDA) a clear picture of the state of the overall enterprise at the outset of LSS application. One key finding of the HICVS map was that it clearly identified the Charleston facility as the “Enterprise Constraint,” meaning that it was the most significant choke point in the entire enterprise. Charleston required immediate attention. Typically, once a HICVS map is produced, hypothesis testing is conducted prior to implementing changes in order to enable leadership to recognize risks and opportunities for improvement in the existing operating environment. However, gaps were so apparent—and time such a critical element—that the ASN (RDA) moved quickly to implement solutions for improving the MRAP operation at Charleston.

To start, Charleston formed a “process improvement team fully devoted to Lean Six Sigma activities.” The team included specially trained process improvement personnel known as black belts and green belts, all working under a master black belt coach. The team began its work by focusing on design of the production lines (of which there were 25) and, in particular, on the two stations which were resident in all of them.

Four key LSS events focused on: point-of-use hardware 5S (sort, set in order, shine, standardize and sustain), navigation and communications

equipment delivery, implementing TAKT boards to monitor process output, and communicating and standardizing Quality Assurance Inspections across all 25 integration lines.

In all, a total of 57 projects were identified from the HICVS analysis and from holding an executive planning session with Charleston's senior leadership. These projects were captured using a Benefits and Efforts chart that provided the team a "battle map" to use to attack the most significant issues.

Results

The results of the LSS activities were profound. The MRAP production lines were transformed from messy and disorganized to neat and efficient. Standardized production support fixtures were introduced.

The LSS team was able to achieve the goal of 50 integrated MRAP vehicles ready for shipment to the warfighter by December 5th 2008. In fact the capacity that was created exceeded demand with production, at times, reaching 69 vehicles per day. This 10 to 14-fold improvement in production was made using the same 25 production lines and workforce.

Much more importantly though, the increased quantities of MRAP vehicles delivered to Iraq saved American lives. In June 2008, USA Today reported that roadside bomb attacks and fatalities were down almost 90% partially due to MRAPs. "They've taken many hits, many hits that would have killed soldiers and Marines in unarmored HMMWVs," according to Admiral Michael Mullen, chairman of the Joint Chiefs of Staff. Major General Rick Lynch, who commanded a division in Baghdad, told USA Today the 14-ton MRAPs have forced insurgents to build bigger, more sophisticated bombs to knock out the vehicles. Those bombs take more time and resources to build and set up, which gives U.S. forces a better chance of catching the insurgents in the act and then attacking them.

This case study illustrates the effectiveness of a highly trained, highly focused LSS team. Beginning with an accurate value stream map allowed the team to better focus their efforts on the most wasteful of processes. Under the dedicated guidance of a Master Black Belt, the team was able to apply LSS tools to eliminate waste, reduce variability and increased quality while simultaneously meeting the increase in demand.

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IV. DMAIC METHODOLOGY

A. INTRODUCTION

In this chapter, we will discuss an incredibly powerful improvement process and the tools associated with each step. As a Six Sigma originator, Motorola was the first to recognize that process improvement followed a pattern that could be divided into five problem solving phases (George, 2002, p. 24). The acronym DMAIC stands for Define, Measure, Analyze, Improve, and Control. DMAIC is a problem solving methodology used to guide a team as they seek to improve a system. DMAIC provides the framework in which teams identify a problem, analyze data, identify root causes of the problem, develop solutions, and establish procedures to ensure solution sustainability. During each stage of DMAIC, specific tools are used to guide project teams.

B. DEFINE

The Define stage of DMAIC is used to identify a problem, agree on a project and design a realistic scope in which to solve the problem. The first step within the Define stage is to write a Project Charter. The Project Charter defines the team's mission but does not solve the problem. The Project Charter provides the framework, the plan, and the goal of the team's project and will change as the project progresses.

The Project Charter consists of six elements, the opportunity or problem statement, the business case, the goal statement, the project scope, the project plan, and team composition. The document allows for a clear and common understanding of why the project is necessary, the potential benefits to the organization, and the monetary value of the project. The problem statement describes the current problem and the issues it is creating within the organization. Specific information on the problem is provided such as when the problem started, where it is occurring and to what magnitude and what specifically is believed to be the root cause of the problem. The business case

provides a common understanding of why the project is being done, what the benefits are to the customer, and a prediction of the monetary value of the project. The goal statement details the deliverables of the project. It outlines improvement objectives and measures of success. The goal statement gives specific information on how the project intends to improve upon the problem.

The next part of the Project Charter is the scope statement, which defines the project boundaries. The scope statement details what teams are authorized to do and what is not within their scope. It may discuss areas that will not be addressed or related issues that can be addressed later. The project plan provides information on how teams are going to complete the project. It provides a timeline and specific goals and milestones, in relation to the DMAIC elements to be met. Team composition is the final element of the Project Charter. It lists the members of the team, what their role is within the team and how much time they are able to dedicate to the project.

The next element of the Define stage is the SIPOC chart. SIPOC stands for Suppliers, Inputs, Process, Outputs, and Customers. Suppliers can be internal or external to the project. Inputs could be raw materials, information, or people. The process is defined by a simple phrase to encompass the entire procedure such as NPS In-processing. Outputs can be anything produced by the process that is of significance to the customer. Finally, the customers are identified as consumers of process production. This SIPOC chart allows teams to begin mapping and analyzing the process by identifying the key individuals or groups affected by the process. The SIPOC chart assists teams in preparation for Voice of The Customer data collection by identifying the customers of the process outputs.

Construction of the SIPOC Chart involves labeling the process beginning with the customer and working backwards to the supplier. The chart may consist of several suppliers, producing multiple outputs, for different types of customers all within one process. It is important for teams to list only those specific suppliers, outputs and customers associated with the identified process. Once

the critical outputs and customers have been identified, teams are ready to move on to data collection in the Measure stage of DMAIC.

C. MEASURE

The Measure phase of DMAIC involves data collection. Documentation is important as team members combine their knowledge and experience to gain critical data that will support their process analysis and improvement recommendations. Customer satisfaction in the service industry is the measure of success. To accomplish this, it is essential to collect Voice of Customer (VOC) data. This information identifies the customer's needs, wants, desires, and specifically those that are not being met or addressed. The details may be intuitive to team members though the data will verify its relevance to the process.

Several methods exist for collecting VOC data. Focus groups, consisting of 10–15 customers who experienced the same process can provide a collective point of view. Interviews can be used at several points along the process and provide a specific customers point of view. A member of the team may also participate as a customer in the process to experience first-hand the associated problems. Indirectly, teams can conduct surveys as a way to gather large amounts of information from process participants. Surveys can be efficient but require teams to carefully consider the questions being asked. Diverse populations may not respond to surveys in the expected manner, which could require teams to identify target groups within the process. Direct observation of the process is important when possible and teams should also consider existing market data or external research that may be relevant to their project.

VOC inputs are analyzed to identify key customer issues which are translated by teams into customer requirements which are specific and more importantly, measurable. Of the customer requirements identified, the most important ones in terms of customer satisfaction and process improvement become Critical to Quality (CTQ) requirements. CTQ requirements address aspects of quality, performance, and expectations as identified by the customer

and represent an area in which the customer sees value. CTQ requirements will form the basis for comparison and focus of improvement as teams move in to the Analyze and Improve stages of DMAIC.

In order to fully understand the process and key areas of data collection a team must complete a process map. Process mapping is used to convert confusing processes into easily digestible and understandable information. The process map combines numerical information with the process to create a visual representation of a process flow. This tool identifies the steps of the process, the resources being used, and the inputs and outputs of the process. This graphical representation is intended to display opportunities for improvement along the process. Information displayed by the process map will lead directly the Value Analysis step in the Analyze stage of DMAIC. It is important that process mapping be done as a team to make use of the collective knowledge. The Process Map is a living document and will change as further data is unveiled. Version control is important as several Process Maps are updated. Teams should maintain a baseline map with which to compare. There are two types of process flow charts, the Top Down Flow Chart and the Deployment Flow Chart.

Top Down Flow Charts begin at the highest level of the process most likely associated with the root problem. In order to get accurate data, several high levels must be identified within the process as potential problem causing areas. The chart then analyzes downward through each of level of the process in an attempt to identify at what lower level the underlying cause or causes of the stated problem begin. From this level, teams can move into the Analyze stage of DMAIC through the Value Stream Map tool.

Deployment Flow Charts are used when diverse departments or several functions within one process may collectively contain the root cause of the problem. The varying functions of many different participants are displayed on a Deployment Flow Chart in linear, step manner. A Deployment Flow Chart can be used to display sequence in time and identify potential areas for cycle time reduction.

Several other tools can be useful in the Measure stage of DMAIC. Despite what tool is used, the importance of personal process observation by team members cannot be overstated. All possible critical points along the process flow should be observed if possible. Time value mapping can be useful in reducing wasted time through identifying areas of value added work. Areas of less value can be reduced or eliminated if no loss to the process occurs. Pareto Charts are useful when focusing on specific problems already identified. Time Series Plots are a useful way to plot the number of defects along a timeline. Despite the tool being used, accurate data collection and documentation is essential during the Measure stage in order to conduct the proper analysis as the DMAIC process moves forward.

D. ANALYZE

During the Analyze stage of DMAIC, teams interpret the data collected during the Measure stage and analyzes it for causes of the identified problem. Teams must look for pattern in data the collected from multiply tools. The focus of proper data analysis is to be able to target for improvement, those areas of most waste or congestion in the process.

As described in Chapter II, steps within the process are analyzed by perceived or required value. Based on information or comments from the VOC data collection, process steps are placed in three categories. Some steps do not add value but are necessary for the process (NVA-R). There may also be steps that add no value (NVA) to the customer. Value Add (VA) activities are those activities within the process that must be performed to meet customer needs or are of such high value to the customer that their willingness to pay for the step is profitable for the process. VAs steps are not necessarily required for a finished product and rarely need reworking. Non-Value Added- Required (NVA-R) activities are necessary for the efficient use of the process but are not seen as particularly valuable by the customer. NVA-R activities could be those required by law or internal regulation or activities whose removal could cause a

breakdown in the overall process. NVA-R should be analyzed and reduced if possible only if their reduction does not affect the VA activities. Activities that do not add value to the customer or are not required by law are seen as NVA activities. NVA activities add waste to the process and should be eliminated.

Value Analysis seeks to identify the step of the process that are important to the customer, identified as Value Add (VA). The purpose of Value Analysis is to eliminate the NVA steps from the process. This will not only reduce cycle time but decrease process costs. By reducing the NVA steps, the process becomes less confusing and less subject to error which will, as a result, increase capacity and improve resource utilization.

Another powerful tool used during the Analyze stage of DMAIC is the Cause and Effect Diagram, also known as the Fishbone Diagram. The Fishbone Diagram is a useful tool when analyzing steps within a process for potential root causes of the problem. Graphically displayed in a shape resembling a fishbone, the diagram ranks potential causes according to their cumulative effect on the problem. The Fishbone Diagram can also display the interaction of root causes within the problem. During the Analyze stage, proper interpretation of the data collected from all applicable tools is essential in identifying those areas that require attention and allow teams to move into the Improve stage of the DMAIC process.

E. IMPROVE

The importance of the Improve stage of the DMAIC process is to make changes based on data and the views of the customer. Process Improvement seeks to improve service quality by increasing capacity, reducing cost and cycle time while improving reliability. Cycle time can be reduced by eliminating the NVA activities and decreasing wait times. The reduction of bottlenecks can also be accomplished through the removal of NVA activities and increasing capacity of bottlenecked resources. Despite the chosen method of process improvement, before any steps are taken, it is essential to analyze the effects of implementing

the changes. Changes could take time or require training and capital. Teams should revisit the stakeholder analysis performed earlier to identify any potential resistance to change. Teams must ensure that the benefits to implementing change outweigh the costs. To do this, teams must weigh all potential changes against potential costs and begin implementation at the lowest cost level.

Improving service quality means understanding the five service quality gaps. The first gap is a misunderstanding of customer expectation. This can result from a poor VOC understanding during the Measure stage, lack of communication from the ground level to upper management, or lack of interaction with the customer. The second gap is adopting less than adequate service quality standards. This can result from the absence of goal setting or a lack of quality commitment by management. The third gap is service performance gap. Poor job fit of technology and people, lack of empowerment, and role ambiguity are all contributing factors to the third gap. Many firms display a propensity to overpromise. Gap four occurs when promises do not match delivery. A disparity in service perception by the organization and service expectation by the customer creates the fifth service quality gap.

Benchmarking can be an important tool to the Improve stage of the DMAIC process. Once a problem is identified, Benchmarking seeks to adapt solutions already in practice by other organizations to solve the issue. Benchmarking can be difficult to implement because it originates from an outside source, but can open up an organization to new and innovative techniques and ideas. Benchmarking will require teams to do a thorough analysis of other organizations within the industry that have experienced similar problems. If possible, teams should visit outside organizations and observe changes in process. Though useful, Benchmarking can have detrimental effects if the data collected during the Measure stage and the interpretation during the Analyze phase are not thorough and accurate.

F. CONTROL

Once the effects of change implementation have been analyzed, service quality improvements made and gaps identified, and potential benchmarked practices are in place, teams can formulate control measure to ensure process sustainability. Proper controls and procedures must be transferred from project teams to the new owner or parent company. Statistical control charts need to be established and are necessary to measure process efficiency.

Process variability is inevitable and must be expected. Proper control charts set appropriate limits of variability and quickly display when a process is out of control. Target value, specification limits, and control limits must be clearly defined and understood by those involved in the process. Control charts can take various forms. They must be applicable to the process and understood by the new owner or parent company. Potential out of control process solutions are identified and prepared for implementation should the new process move out of control.

V. DMAIC APPLICATION

Chapter V details the bulk of the team's research. Using the DMAIC process as described in Chapter IV, the team began on June 1 2012 by writing the team charter. Research continued through new student orientation and follow-up Voice of The Customer (VOC) questionnaires and analysis.

A. DEFINE

The DMAIC process began by building the team charter. The Project Charter defined the problem and outlined the team's goals for improvement. The Project Charter also provided the framework and scope of the team's LSS research. With input from the Flag Administration Officer, NPS Student Services, and the current student body, the team defined the problem. It was hypothesized that a lack of communication between the school and military branches as well a poorly organized process contributed to inefficiencies in the NPS student in-processing system. By determining what procedures were absolutely necessary and consolidating those steps into one location, the team believed that overall cycle time could be reduced by 60% and student compliance with check in requirements could increase to 90%. It was determined that foreign student in-processing would be out of the scope of the research based on the diversity of requirements and relatively small sample population. The charter existed as a living document. As we progressed through the DMAIC process, the charter was updated to reflect newly discovered problems and adjustments to goals.

Naval Postgraduate School
MBA Thesis Project
Project Charter – “LSS Analysis of Student In-processing”

Date: 1 August 2012 **Project No. & Name:** No. 1 – LSS Analysis of Student In-processing
Project Team Leader: Major Patrick Clary, USA
Project Sponsor: NPS Flag Admin Officer **Project Champion:** NPS Student Services

Problem/Opportunity Statement:

1. During the past 12 months, the Flag Administration Officer has received several complaints from students concerning the inefficiency of the new student in-processing method.
 2. The current student in-processing method is confusing, timely and wasteful of school and service resources.
 3. There is little coordination between the different military branches and the school concerning school specific and service exclusive check-in requirements.
 4. Bottlenecks form at several locations within the process creating poor resource utilization and frustration on the part of the school, service, student and student family.
-

Business Impact:

1. Reduced total cycle time of student in-processing.
 2. Improve quality of in-processing experience for service member and family.
 3. Reduce variability of process to ensure required compliance at all required check-in stations.
 4. Increase quality of service provided by NPS administration and staff through greater organization and process understanding.
-

Goal Statement:

1. Reduce total cycle time from 5 days to 2 days by consolidating and re-organizing required student in-processing procedures.
 2. Ensure new students complete 90% of the check-in requirements during 2 day in-processing timeline.
 3. Increase the positive value of student and family in-processing by increasing total quality service by 30%.
-

Project Scope:

Start and stop point of process: The process begins when a new student starts the in-processing process. The process ends when the student is fully enrolled with the school and all necessary subordinate elements.

In scope: NPS specific in-processing requirements.

Out of scope: Service specific in-processing requirements other than NPS service reps. Foreign student in-processing.

Project Plan/Timetable:

Define	1 June 2012 – 15 June 2012
Measure	25 June 2012 – 24 Aug 2012
Analyze	25 Aug 2012 – 1 Sept 2012
Improve	3 Sept – 8 Sept 2012
Control	Future In-processing

Project Team:

Major Patrick Clary, USA
Major Russell Tuten, USMC

Figure 1. Team Charter

The next step in Define development is to take a high level view of the entire process. Defects can relate to anything that makes a customer unhappy;

long lead time, variation, etc. A clear understanding of NPS in-processing was needed before the identification of problem sources began. In order to accomplish this, the team developed a SIPOC chart. As discussed in the DMAIC process background (Chapter IV) SIPOC stands for Supplier, Inputs, Process, Outputs, and Customer. This SIPOC chart allowed the team to begin mapping and analyzing the process by identifying the key individuals or groups affected by the process. The SIPOC chart assisted the team in preparation for VOC data collection by identifying the customers of the process outputs. Figure 2 displays the in-processing SIPOC chart.

NPS IN-PROCESSING SIPOC CHART				
Suppliers	Inputs/Req'ts	Process	Outputs/Req'ts	Customers
		Student In-processing	-Graduate Student prepared for class	
USMC	Marine Officers	↓ Student Services Travel Office	-Required info collected by tenant organizations	NPS
		↓ Security Clearance DAPA	-School and local information disseminated to student body	
USA	Army Officers	↓ Fleet and Family Ed Rep	-Settled families	Student
		↓ Medical Urinalysis	-Geographical orientation to the area	
USN	Naval Officers	↓ Admin Service Rep	-Complete travel claims	Tenant organizations
			-Complete within 5 days	

Figure 2. SIPOC Chart

For this project, the suppliers are the three main DoD services that send students. The inputs are the offices which they provide. The process is the NPS

student in-processing process which involves ten main steps. The outputs are the general requirements sought by the process and represent the critical to quality (CTQ) indicators:

1. Student prepared for class—students receive and understand schedule of classes.
2. Required info collected by tenant organizations—In-processing station gathers the information necessary from student to complete enrollment.
3. School and local information disseminated to student body—School and local organizations familiarize students with their services.
4. Settled families—Families complete move into appropriate housing.
5. Geographical orientation to the area—Students become familiar with school and local area geography.
6. Completed travel claims—Students complete travel paperwork.
7. Complete within 5 days—The process is complete within 5 days and in-processing sheet returned to Student Services.

The process has several customers. The school itself must gather information on the student body to ensure proper enrollment. The school must also educate the students on the policies and procedures of NPS to ensure a smooth transition from military officer to graduate student. The students themselves are customers in that they receive important information necessary to begin their graduate education. Several tenant organizations such as Navy Dental, Army Medical and Fleet and Family Services are also customers. They receive important health and family information from the students as they move through the process.

B. MEASURE

The measure phase began with the construction of the student in-processing Process Flow Chart (Figure 3). The Process Flow Chart is a graphical representation used to display the process in a clear and understandable manner. As with the Project Charter, the Process Flow Chart is a living document and was updated as the team gained more understanding of the process.

With no prescribed order in which to complete to ten stations, it was unable to design a single, specific process flow. Students can begin the process at any location and proceed at their discretion to any of the ten station locations. This immediately raised concerns with variability and process control within the process flow.

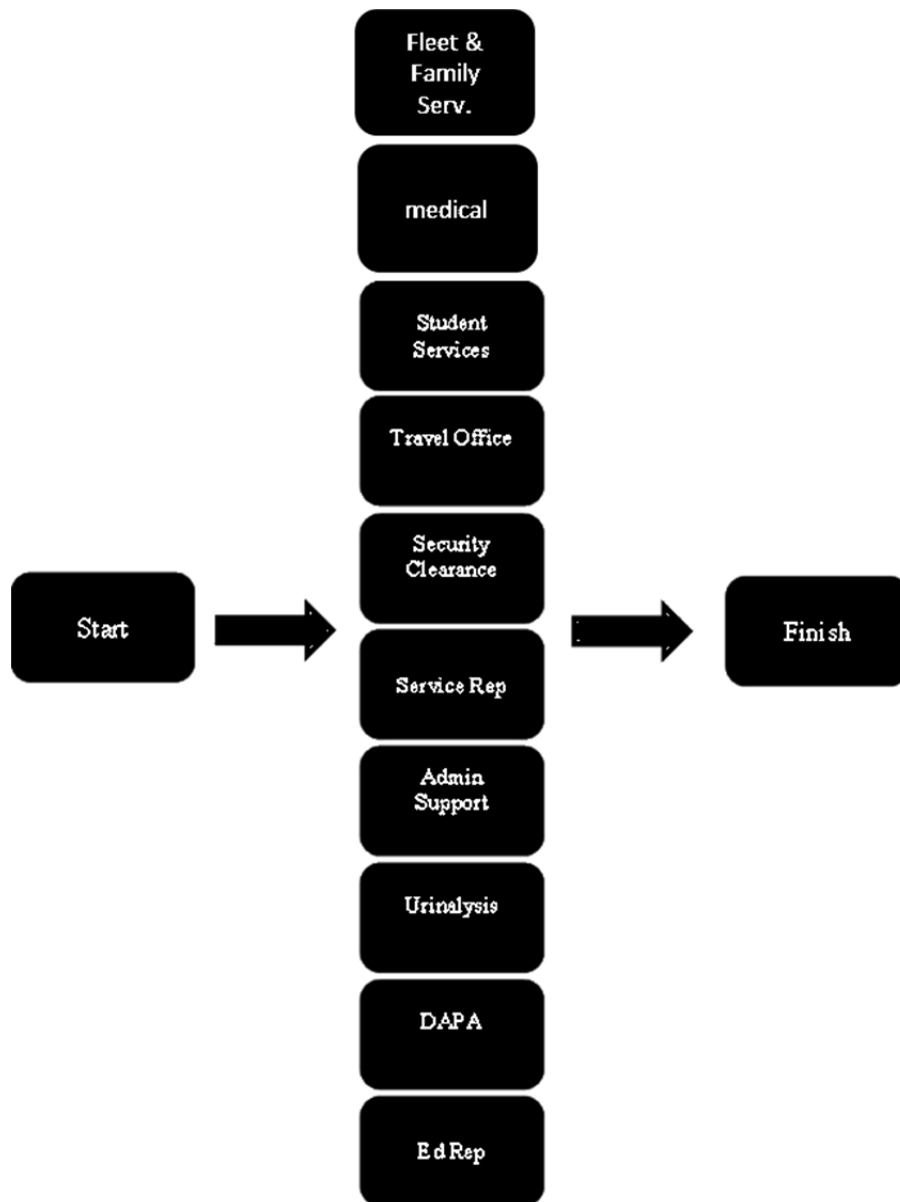


Figure 3. Process Flow Chart

As former participants in the system, the team members reflected on their own experiences and began brainstorming in an effort to identify potential root causes of the inefficient system. From analyzation of the Process Flow Chart, personnel experience and conversation with students of the same class, a central theme of process ambiguity and a decentralized process revealed itself. Potential causes of these issues included redundant paperwork, multiple station

locations, a confusing check in-sheet and unnecessary requirements. In addition, the three major services represented at NPS have service specific check-in requirements.

With this understanding, the team decided to collect data in two phases. First, data concerning process flow was collected from the incoming summer class. Second, the team decided to conduct a VOC survey of the same new students. The VOC survey was given two months after student in-processing and sought to assess the quality of the in-processing procedures as seen from the view of the customer.

C. ANALYZE

Data collection began on June 25th, 2012 with the arrival of the new student class. Twenty-three students completed surveys (encl. 2, Data Survey Sheet). The surveys identified ten areas of new student in-processing as identified by the new student check-in sheet:

1. Student Services: Located in Hermann Hall, inputs basic student information into the NPS data base and produces the NPS identification card.
2. Travel Office: Located in Hermann Hall, processes government travel charge card claims.
3. Security Clearance: Located in Glasgow Hall, verifies the security clearance status of every student.
4. Drug and Alcohol Program Advisor (DAPA): Located in Hermann Hall, ensures that every student has received annually required drug and alcohol education.
5. Urinalysis: Located in Spanagel Hall, conducts urinalysis as part of a drug-screening process.
6. Fleet and Family Support Center: Located in the La Mesa housing community, provides family services and information about the Monterey peninsula area.

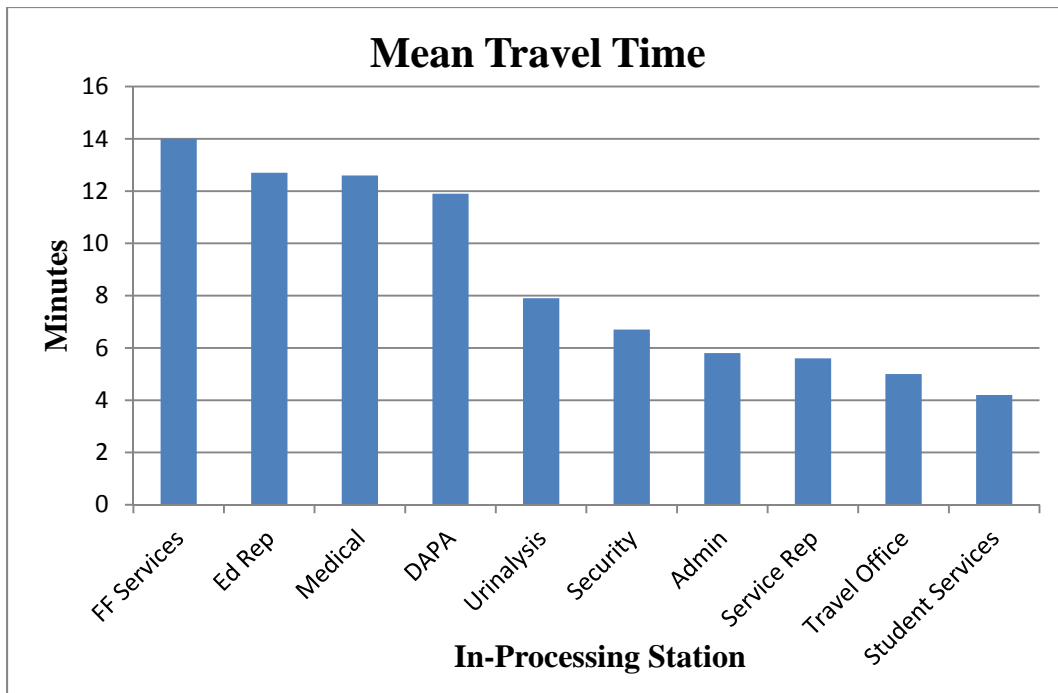
7. Educational Representative: Various locations depending on curricula, provides the student curriculum specific information.
8. Medical: Located at the Army Medical Clinic at the Presidio of Monterey, receives and maintains the student's medical records while they are at NPS.
9. School Administration: Various locations depending service, provides administrative support to include travel claim processing.
10. Service Specific Representatives: Various locations depending service, provides the student with service specific expectations while in student status.

Of the ten stations, each student was asked in what sequence they visited the station, how much travel time was required to reach the station and how much time was required to complete the station. With this data, the team updated the process flow chart (Figure 4) to represent total mean station time. The numbers associated with each station represents the mean travel time plus mean station time in minutes.



Figure 4. Process Flow with Data

There is no prescribed order in which to visit each station. Students are free to flow through the process at their own design.

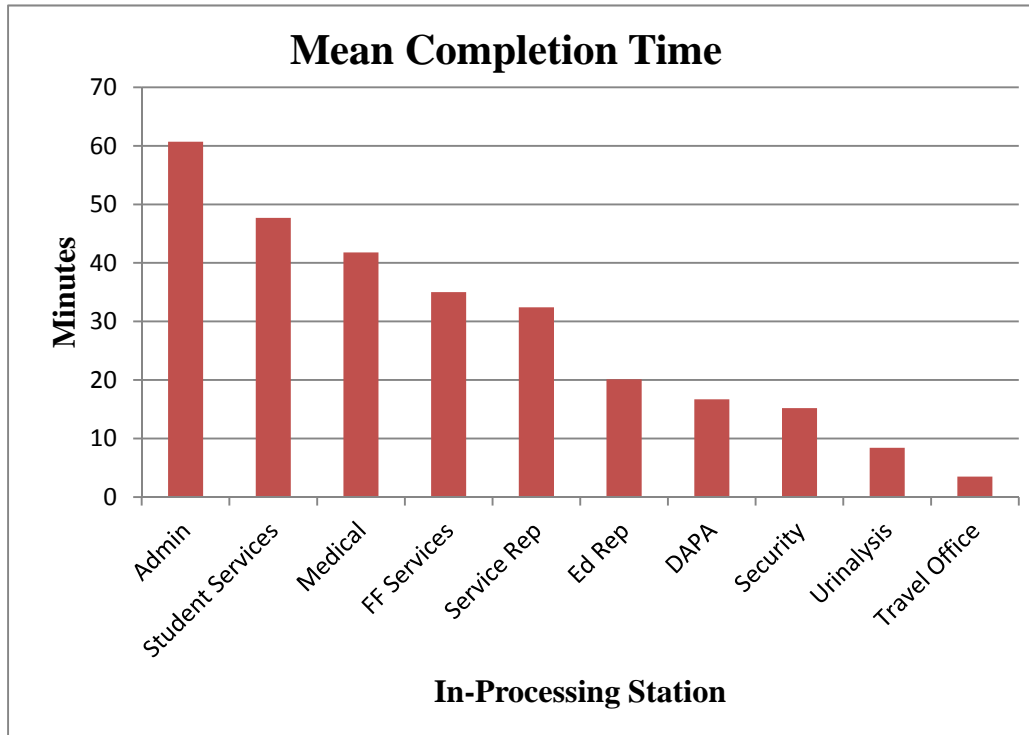


In-Processing Station	Mean Travel Time in Minutes
FF Services	14
Ed Rep	12.7
Medical	12.6
DAPA	11.9
Urinalysis	7.9
Security	6.7
Admin	5.8
Service Rep	5.6
Travel Office	5
Student Services	4.2

Table 2. Mean Travel Time by Station

The total mean travel time to all stations is 86.3 minutes or 1.4 hours. Travel time accounts for 23% of the total mean in-processing time.

Mean completion time represents the time required to complete each station. Mean completion times by station are depicted in Table 3.

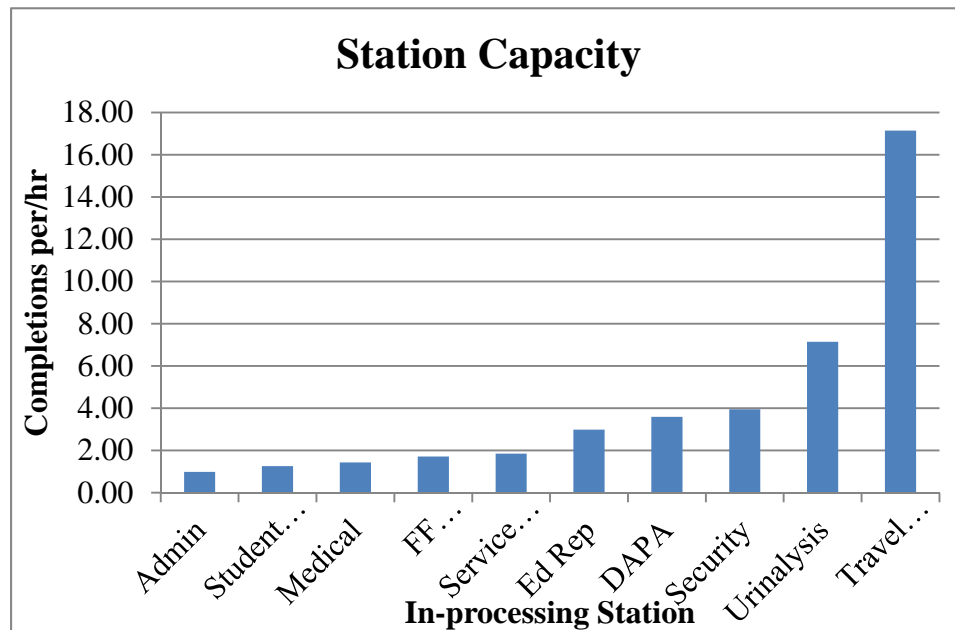


In-Processing Station	Mean Completion Time in Minutes
Admin	60.7
Student Services	47.7
Medical	41.8
FF Services	35
Service Rep	32.4
Ed Rep	20.1
DAPA	16.7
Security	15.2
Urinalysis	8.4
Travel Office	3.5

Table 3. Mean Completion Time

The total mean time required to complete all stations was 281.3 minutes or 4.7 hours. The total mean time to complete all check-in requirements to include travel time is 367.6 minutes, or 6.1 hours.

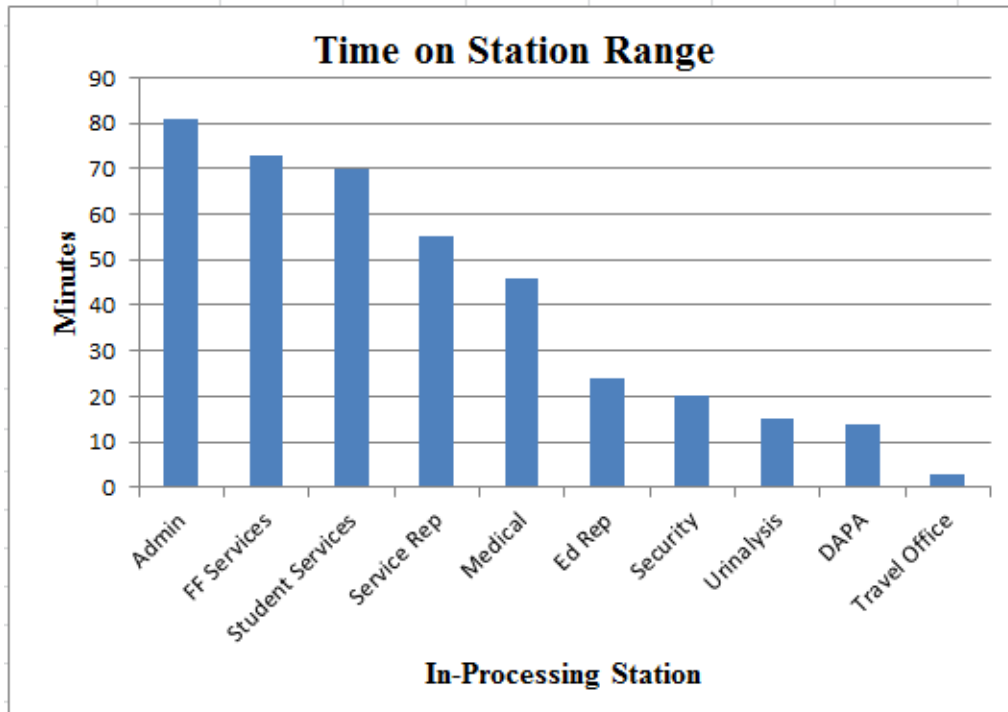
Given the sample mean time on station requirements outlined in Table 3, station capacity was computed. Station capacity output per hour was calculated by dividing 60 by the mean completion time of each station.



In-Processing Station	Mean Station Capacity/hour
Admin	0.99
Student Services	1.26
Medical	1.44
FF Services	1.71
Service Rep	1.85
Ed Rep	2.99
DAPA	3.59
Security	3.95
Urinalysis	7.14
Travel Office	17.14

Table 4. Station Capacity

Significant variation in time on station occurred at several of the check-in locations. Student Administration saw the highest variance with the shortest time on station at 9 minutes and the longest at 90 minutes. The Travel office was the most consistent with a time on station variation of only three minutes. Variation in the system is caused by an inconsistent process flow. The time on station requirement changes depending on when a student arrives at the station. For example, a student may arrive at the NPS Administration office and find ten other students in line, waiting, or they may find none. Due to the current system variation, it is difficult to determine an accurate total mean time on station. Time on station ranges are depicted by Table 5:



Time on Station Range in Minutes			
	Mean	Stdev	Range
Admin	60.7	24.0	81
FF Services	35	24.4	73
Student Services	47.7	25.3	70
Service Rep	32.4	17.6	55
Medical	41.8	16.5	46
Ed Rep	20.1	8.6	24
Security	15.2	6.2	20
Urinalysis	8.4	4.9	15
DAPA	16.7	4.5	14
Travel Office	3.5	1.1	3

Table 5. Station Variation

With no prescribed completion format, wide variation also occurred in sequence of station visited. Two stations did however, produce distinctive results. Forty-three percent of the sample population completed Student Services first whereas 52% completed the travel office second. This would seem appropriate as suggested by the mean travel time chart which shows student service and the

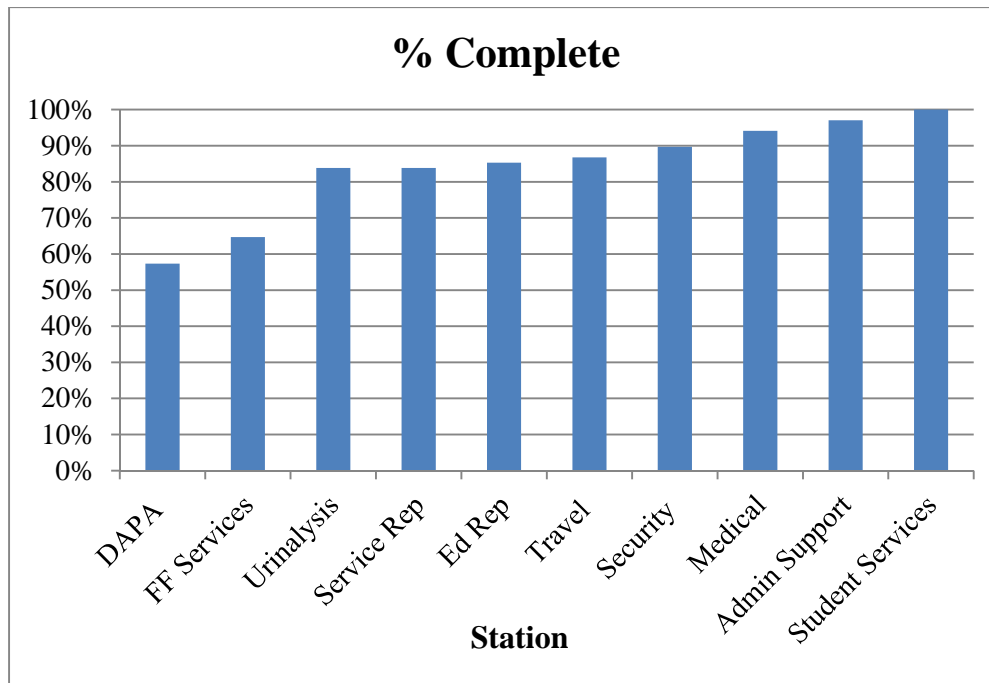
travel office as having the lowest travel times. The close proximity of the two stations would lend credence to the closeness of sequence completion. No other stations displayed such low variation in sequence completion.

1. Voice of the Customer

Process improvement involves identifying the customer's needs, wants, desires, and specifically those that are not being met or addressed. In order to identify these elements, A Voice of The Customer (VOC) survey was conducted two months after in-processing to gauge student reaction to the overall process (encl 3, VOC data sheet). The same ten stations used during the initial check-in were used for the VOC survey. For each station, students were asked to quantify their level of satisfaction in three areas: time required to complete the station, quality of service at the station, and station organization. Each station was ranked on a scale from 1, representing the lowest level of satisfaction to 5, representing the highest level of satisfaction. They were also asked four open ended questions:

1. What part of the process was the most difficult to complete?
2. What part of the process was done well?
3. What would have made the student in-processing experience better for you?
4. Any additional comments?

While the ranking numbers did not display any distinctive trend, the amount of stations not completed (marked N/A) by the students did reveal some useful information which may point to non-value added steps in the system. As displayed by the chart below, of the 68 students surveyed, less than 60% completed the Drug and Alcohol Program Advisor (DAPA) station while only 65% completed Fleet and Family Support Center. The only station completed by 100% of those surveyed was student services.



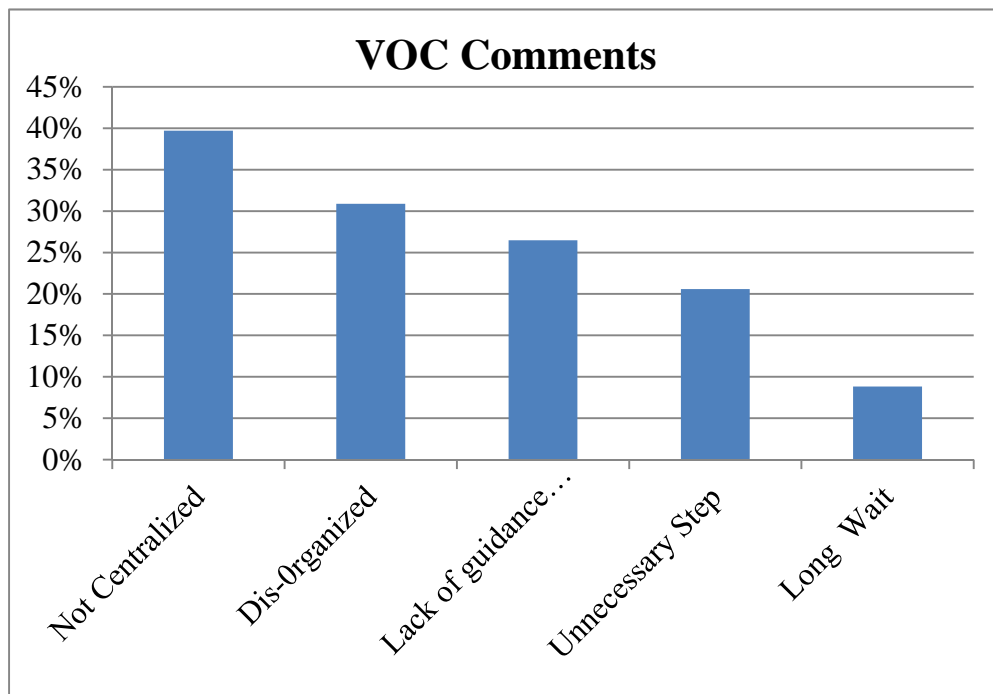
Station	% Complete
DAPA	57%
FF Services	65%
Urinalysis	84%
Service Rep	84%
Ed Rep	85%
Travel	87%
Security	90%
Medical	94%
Admin Support	97%
Student Services	100%

Table 6. Station Completion

Of the 68 surveys conducted, 86 negative comments or suggestions for improvement were submitted. A study of the answers and comments made in response to the four open ended question revealed five general themes. Forty percent addressed a lack of centralization of stations, 31% expressed frustration with dis-organization in the process, 26% mentioned a general lack of guidance or direction, 21% claimed that there were unnecessary steps in the process, and

9% claimed to have experienced frequent long wait times. These comments are the CTQ components from the perspective of the customer and are the driving elements of the Improve phase of DMAIC.

In order to validate the results, an independent analysis of the VOC comments was conducted by a secondary individual. Using the same five themes as a guide, validation needed to be within 5% of the original analysis. The results of the secondary evaluation were within 3% of the original analysis.



VOC Comments	
Not Centralized	40%
Dis-Organized	31%
Lack of guidance on location/process	26%
Unnecessary Step	21%
Long Wait	9%

Table 7. VOC Comments

Under the lack of centralization theme, students frequently commented on the diverse location of several stations and the difficulty in locating them. Fleet and Family Support Center and check in stations at the Defense Language Institute were the most frequently mentioned. Many of the disorganization comments stemmed from a lack of centralization but also frequently mentioned a lack of staff preparedness or availability. Several students mentioned an inability to complete the urinalysis due to key staff being on leave. With only one station completed by all surveyed students, the frequent mention of unnecessary steps in the system is not surprising. In addition, several surveys claimed that the students are no longer required to turn in their check-in sheets upon completion, which brings into question the necessity of the entire procedure. Long wait time comments were most commonly addressed to the NPS Administrative Support check-in station.

Before the surveys were given, the team used some of its brainstorming ideas to develop a cause and effect diagram. The cause and effect diagram, or fishbone diagram is used to identify potential root causes and the cumulative effect of several causes on the problem. The team updated the cause and effect diagram to visually display the most frequent negative comments or suggestions made on the VOC survey sheet.

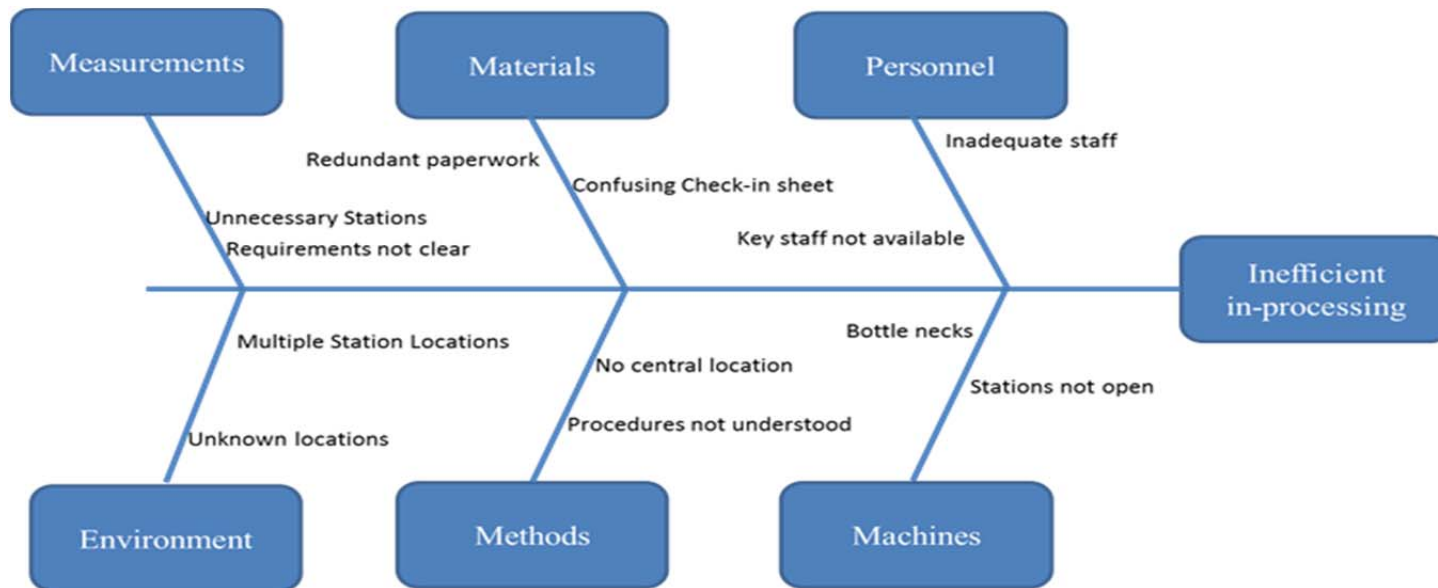


Figure 5. Original Cause and Effect Diagram

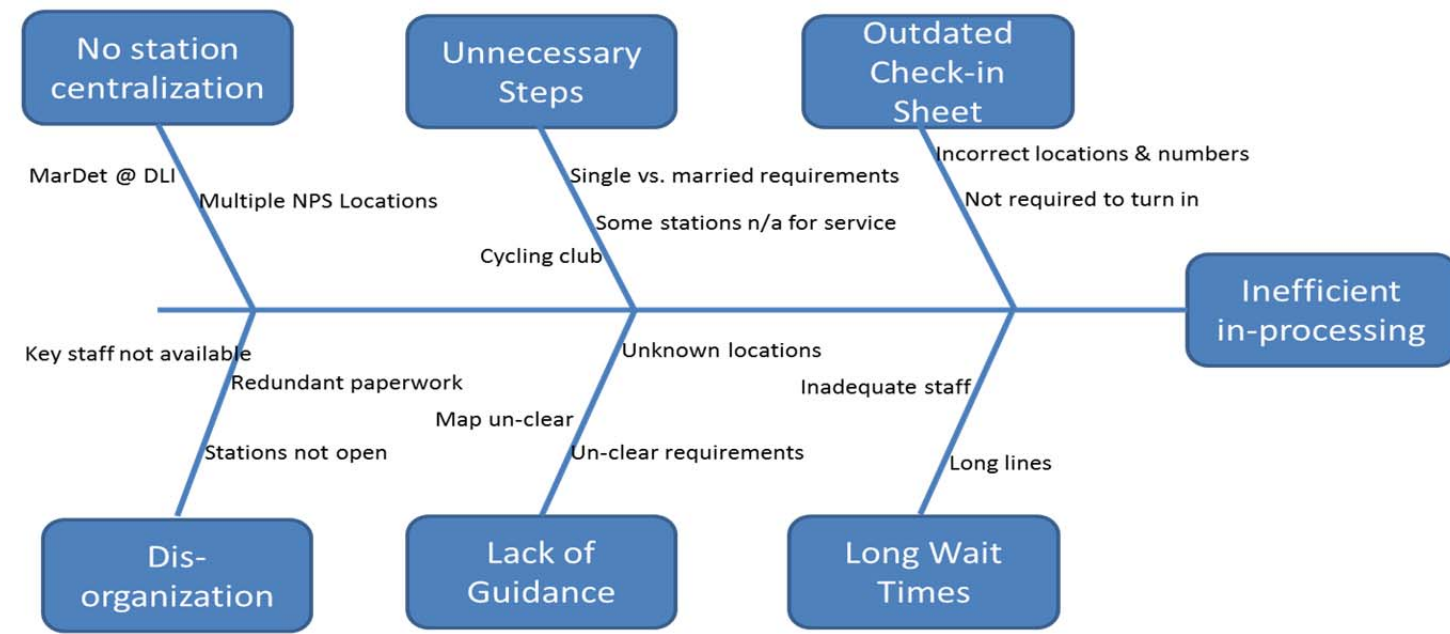


Figure 6. Updated Cause and Effect Diagram

Though not representing a significant percentage of the comments, a few specific suggestions for improvement deserve mention. Several students mentioned that the check-in sheet was out of date, adding to the general confusion experienced during check-in. Several more suggested that an improved and updated welcome aboard package, sent three to six months in advance, would greatly improve the in-processing experience.

D. IMPROVE

Based on the VOC surveys, lack of centralization and dis-organization were identified as the most prominent areas of concern and should be the primary focus of improvement efforts. Five suggestions for improvement are made:

1. Redesign the check in sheet so stations that are close to each other are listed together. The clustering of check in stations will assist the student in better managing the travel time required for in-processing. Clustering may also decrease some of the confusion associated with locating check-in stations. Benefits of this improvement step include:

1. Decrease in confusion associated with station location
2. Decrease in total travel time.
3. Improve perception of process organization

There is distinct variation in service specific check-in requirements. The three services process student paper work in three separate locations. Consolidation of service specific requirements would be a significant improvement though it may be out of the scope of this research. If out of scope, service specific check-in requirements should be eliminated by from the NPS check-in sheet and handled separately by each service.

2. Consolidate documents that require the same or similar information. Redundancies in paperwork and lack of preparedness on the part of the student and the station added significant NVA time. Consolidation of redundant paperwork is a simple step towards improvement. Much of the information required of the students by the stations is redundant. An electronic, universal data sheet could be promulgated by Student Services and the results could be shared with all stations. Benefits include:

1. Reduce time on station requirements.
2. Improve perception of process organization.
3. Decrease variation in student information collected.
4. Potential elimination of requirement for student to visit the station
5. Reduce staff requirement at each station.

3. Send an electronic Welcome Aboard package to incoming student six months prior to arrival. Include in the package all required forms and information from all stations and an updated and accurate map of on and off campus station locations. This change will decrease time on station requirements as well as travel time. It will also reduce variation in station completion and could eliminate the requirement to visit some station all together. This change will improve all the areas of concern expressed in the VOC comments.

4. Reduce NVA steps by customizing check-in sheets to reflect specific groups of students. Based on completion percentages, DAPA and Fleet and Family Support Center are good candidates for elimination. DAPA familiarizes officers with the Substance Abuse and Rehabilitation Program (SARP). DAPA and SARP familiarization are annual requirements for all military members. The information is covered during the school year at an all hands briefing and though important, is redundant in nature. The Fleet and Family Support Center provides information about Monterey Peninsula, primarily for military families. The Fleet

and Family Support Center is located in the La Mesa Family Housing Community which makes it less likely to be visited single service members. Several Navy students stated that they were not required to visit their service rep. Reducing NVA steps in the process will reduce the perception that unnecessary steps exist in the system. It will also reduce total lead time. The elimination of DAPA and Fleet and Family Support Center will:

1. Reduce process lead time from 367 minutes to 280 minutes. An improvement of 24%.
2. Decrease travel time from 86.3 minutes to 60.4 minutes. An improvement of 30%.

5. Consolidation of all check in stations into one location at the same time will produce the most significant improvements to student in-processing. Check-in stations could be consolidated in the large ballroom of Hermann Hall which will not only showcase the beauty and history of the Naval Postgraduate School but also provide an inviting environment for the entire family to participate in student in-processing. In-procession could be conducted over two days with half the new student body attending on each day. Centralization of student in-processing would:

1. Reduce process lead time from 367 minutes to 272 minutes. An improvement of 26%.
2. Improve process velocity from 0.25 to 0.63. An improvement of 32%.
3. Improve completions per hour from 10.93 to 27.31. An improvement of 150%
4. Improve the quality of the product in the eyes of the student by eliminating the confusion of station locations.
5. Virtually eliminate travel time.
6. Reduction in time on station variation

7. Improve station completion from 84% to 100%, which will improve the quality and quantity of required information gathered by the NPS check-in stations.
8. Improve the experience as perceived by family members which will have intangible but quality benefits.

Given the current the current station capacity, however, a significant increase in workers per station will occur for most stations. This increase in requirement is based on the current demand of 437 new students and completion of the entire process within a 24 total work hours. 24 work hours was picked to represent the minimum process improvement goal as outlined in the project charter. The team believes that station centralization in combination with any or all recommendations will significantly increase station capacity and therefore, reduce the requirement for additional workers per station.

In-Processing Station	Mean Station Capacity/hour	Workers required for completion in 24 hours
Admin	0.99	23
Student Services	1.26	19
Medical	1.44	16
FF Services	1.71	14
Service Rep	1.85	13
Ed Rep	2.99	8
DAPA	3.59	7
Security	3.95	6
Urinalysis	7.14	4
Travel Office	17.14	2

Table 8. Station Capacity and Demand

For the sake of comparison, the increase worker requirement was calculated by using the minimum station completion time as observed by the first

round of data collection. Though ideal in its outlook, with consolidation, the team believes the increase in worker requirement is more accurately represented by the minimum station completion times.

In-Processing Station	Min Station Capacity/hour	Workers required for completion in 24 hours
Admin	6.67	4
Student Services	4.00	6
Medical	6.67	4
FF Services	30.00	1
Service Rep	12.00	2
Ed Rep	6.00	4
DAPA	6.00	4
Security	12.00	2
Urinalysis	30.00	1
Travel Office	30.00	1

Table 9. Potential Capacity and Demand

The Stakeholder Analysis discussed in Chapter I was revisited and assessed based on the five recommendations for improvement. The team assesses Flag Administration as a very supportive stakeholder. All recommendations for improvement will benefit the Flag Administration and require minimal change or extra work. The students will also benefit from implementation of any recommended change. They seek to gain the most from consolidation. NPS Administration will be marginally supportive in four of the five categories due to a slight increase in workload required. Consolidation will create extra work for them in coordination with external services.

While resistance from POM Medical is expected, it is predicted that they will be unsupportive of consolidation because it will require them to temporarily relocate staff and supplies to NPS. Student Services will likely be the most resistive to change. All recommendations, while improving the system, will

increase their workload. Student Services will have to significantly change the way in which they do business and, in many cases, become the manager of student in-processing.

	Station Cluster	Document Consolidation	Welcome Aboard Package	Specialized Check-in sheets	Consolidation
Flag Admin	1	1	1	1	1
Student Serv.	2	4	2	2	2
NPS Admin	1	2	2	2	4
Students	1	1	1	1	1
POM Medical	1	2	4	4	3

1=Supportive 2=Marginal 3=Non-Supportive 4=Mixed Blessing

Table 10. Stakeholder Analysis

E. CONTROL

The purpose of control is to ensure that the identified improvements have a sustainable and lasting effect on the process. Continual monitoring of the system is required to ensure that the changes have the desired effect. Control charts can be used for these purposes.

Control charts are used to determine if the process is operating within statistical control or if the process performance has degraded and if determination and elimination of a specific problem is needed. Because the success of the NPS student in-processing process is heavily dependent on the view of the customer, a useful control chart would be one that displays customer satisfaction.

To measure this, a final step could be added to the check-in process. By cohort, students would be given an anonymous questionnaire and asked to rate their level of satisfaction on the overall process on a scale of zero to five, five being the highest level of satisfaction. Marks of four and five would be considered satisfactory. Anything below that would be considered unsatisfactory. A percentage of satisfied students for the entire cohort would then be calculated:

$$P = \frac{\text{\# of students giving a rating of 4 or 5}}{\text{Total \# students in cohort}}$$

Similar to the voice of the customer questionnaire, students would also be provided space to make voluntary recommendations for process improvement or comments on parts of the process that were done well.

Student Services would be responsible for gathering the data and creating a simple p-chart. A p-chart is a type of control chart that has upper and lower limits and displays points representing process performance. The upper control limit (UCL) and lower control limit (LCL) are computed using statistical analysis of data and use of specific formulas (George, 2002, p. 197). A p-chart would clearly identify a cohort when sufficient numbers of students were not satisfied with the process. Points between the upper and lower control limits would represent an in-control process. Points below the LCL would display cohorts when there are large numbers of unsatisfied customers. The responses for that cohort would be retrieved and checked for reasons of dissatisfaction. Points that are above the UCL mean that students were extremely pleased with the process and their questionnaires might give praise to specific areas point to value added steps in the process. The UCL and LCL can be adjusted to allow for a wider or narrower range of mean satisfaction level.

Figure 7 presents a hypothetical p-chart that can be used to better understand how this control chart can be used in practice. As shown in Figure 7, the percent of satisfied students for the first six cohorts are within the UCL and LCL and hence it is reasonable to assume that the process is “in control.” In

other words, the process is performing in a normal manner and the change in percentage of satisfied students from one cohort to the next is primarily due to random fluctuation one can expect from any process. The percentage of satisfied students for cohort 7, however, has dropped below the LCL indicating that the process might be “out of control.” A less than acceptable percentage of students from cohort 7 are not satisfied with the process. Cohort 7 questionnaires need to be retrieved and the responses analyzed for reasons of dissatisfaction. Where possible, corrective measures need to be taken, within the process, to improve the points of dissatisfaction.

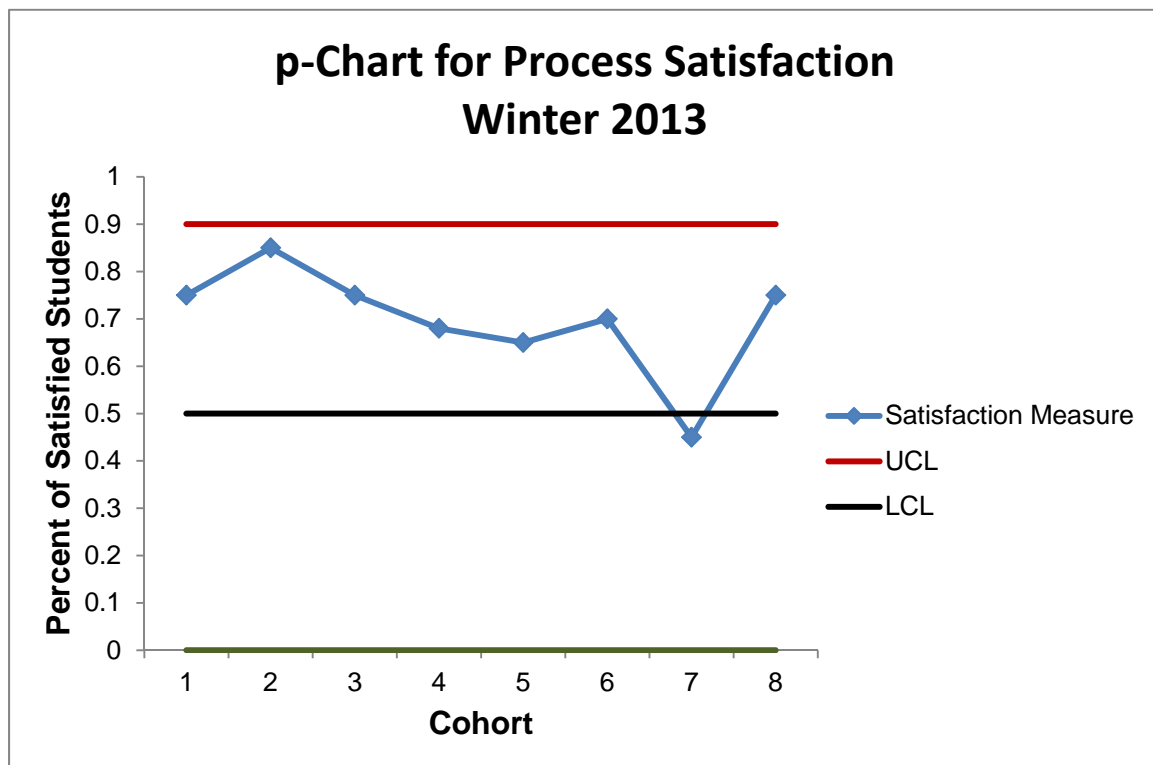


Figure 7. Control Chart

With any implementation of change, control of the system will rely heavily on managerial supervision. An appropriate model for institutionalization of LSS changes to NPS student in-processing involves four steps: comply, commit, embed, and encode (George pp. 227–228). Embedding LSS changes involves

each of the stakeholders institutionally altering the way in which they do business. They must realize the effects the changes have on their customers and efficiently train their staff to operate within the new system. Encoding ensures commitment to long term change and success. At this stage, the stakeholders embrace the new system as the way of business. It is no longer viewed as a new system but as the system. Each stakeholder will need to rewrite their regulations governing student in-processing methods. Success will come with commitment.

The responsibility for control ultimately rests with the leadership and the belief that change benefits the customer in a way that improves the process as a whole. The value gained by the customer must be viewed as outweighing the cost of the change. An improved student in-processing system will enrich the educational experience of military officers and their families and ensure that NPS resource and staff are used in an effective and efficient manner.

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APPENDIX

A. VOICE OF CUSTOMER SURVEY

NPS STUDENT IN-PROCESSING CUSTOMER SURVEY

Circle Branch of Service: Navy

Army

Air Force

Marine

Please rate the following based on your in-processing experience. 1=Lowest, 5= Highest

	1	2	3	4	5	N/A
STUDENT SERVICES						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
TRAVEL OFFICE						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
SECURITY CLEARANCE						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
DAPA						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
URINALYSIS						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
FLEET & FAMILY SERVICES						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
ED. REPRESENTATIVE						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
MEDICAL						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
ADMIN SUPPORT						
1. Time required to complete						
2. Quality of service						
3. Station Organization						
SERVICE REPS						
1. Time required to complete						
2. Quality of service						
3. Station Organization						

1. What part of the process was the most difficult to complete?
2. What part of the process was done well?
3. What would have made the student in-processing experience better for you?
4. Additional comments.

B. DATA COLLECTION SHEET

Lean Six Sigma: Improve Student In-Processing
Data Collection Sheet

Branch of Service: _____

Stations	Sequence No.	Travel Time to Station	Time Start at Station	Time Finish at Station
Student Services				
Travel Office				
Security Clearance				
DAPA				
Urinalysis				
Fleet & Family Services				
Ed. Representative				
Medical				
Administration Support				
Service Reps				

Instructions:

1. Students can go to stations in any order
2. Students give the sequence order they go to each station (1 thru 10)
There are two additional blank stations for anything that the student in-processes outside the first ten.
3. Students write down the travel time to each station
4. When Students get to each station they will write down the time that they started that station and will write down the time when they have completed that station.
5. After all the stations have been completed, please turn Data Collection Sheets into the box in student services labeled **Lean Six Sigma Data Collection Sheets**
6. Your participation is totally voluntary
7. The information provided will be used to analysis student in-processing at the Naval Postgraduate School and work towards improving the process in the future.

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